

relevant for much of his early acoustical research. He did not have any formal scientific education. In 1816 he was apprenticed to an uncle in the music business in London. Although Wheatstone became directly involved in the music business in 1823, he worked mainly on practical musical inventions (he patented the concertina in 1829) and on experimental studies of acoustic vibrations. His early work in acoustics became known (some of his papers were translated into French and German), and he was appointed professor of experimental physics at King's College, London, in 1834. He gave some lectures on sound, but most of his work consisted of research in electricity and in optics. Many of his results were communicated by Faraday. In 1836 he became a fellow of the Royal Society, he was knighted in 1868, and in 1873 he was made a foreign associate of the Paris Academy of Sciences. He received many other scientific honors.

Wheatstone's interest in acoustics was basically inspired by his desire to understand properties of a tone, such as timbre, in terms of vibration.¹ During the fifteen years that he worked on acoustics, he investigated the mechanical transmission of sound, visible demonstrations of vibrations, and properties of the vibrating air column (the Wheatstone family was involved in the making of flutes). When he was nineteen, he publicly exhibited an "enchanted lyre" that was activated by the vibrations from a remote piano transmitted to it along a wire. In Wheatstone's kaleidophone (1827) the free end of a vibrating rod was illuminated to provide a visual display of vibration. Because of persistence of vision, one saw intricate curves characteristic of the vibrational modes. Wheatstone was interested in Chladni's sand pattern technique for displaying the vibrational modes of a plate, and in 1833 he tried to use the sand patterns of a square plate to demonstrate the superposition of vibrational modes. In 1832 Wheatstone demonstrated that in the case of a standing wave in an open pipe, the motions at the ends are in opposite directions.² He used a pipe bent into a circle so that its ends were on either side of a vibrating square plate; when the ends faced the same region of the plate there was no resonance, but when they faced different regions (which moved in opposite directions), the resonance was strong.

In electricity one of Wheatstone's earliest and most important works (1834) was the measurement of the velocity of an electrical discharge through a wire. Wheatstone had the idea of studying very rapid motions by reflection from a rotating mirror. After trying unsuccessfully to "draw out"

WHEATSTONE, CHARLES (*b.* Gloucester, England, 6 February 1802; *d.* Paris, France, 19 October 1875), *physics*.

Wheatstone was an experimenter and pioneering inventor in acoustics, optics, electricity, and telegraphy. He came from a family of musical instrument makers and dealers, a background that was

the spark produced by an electric discharge, he used the rotating mirror technique to observe the intervals between sparks produced by a single discharge across three spark gaps, located side by side and connected to each other by quarter-mile lengths of copper wire. From the displacement of the middle spark relative to the other two, he estimated the velocity of electricity to be over 250,000 mi./sec. (1.3 times the velocity of light³). In 1838 Arago suggested that Wheatstone's rotating mirror technique be used to compare the velocities of light in air and in water—an experiment performed by Foucault and Fizeau in 1850. The technique was also used by Lissajous from 1855, to study acoustic vibrations.

In 1843 Wheatstone published an experimental verification of Ohm's law, helping to make the law (already well known in Germany) more familiar in England. In connection with the verification he developed new ways of measuring resistances and currents. In particular, he invented the rheostat and popularized the Wheatstone bridge, originally invented by Samuel Christie.

In the early years of his acoustic experiments Wheatstone had speculated on the possibilities of conducting sound (including speech) over long distances,⁴ and his experiments with the electric telegraph date from the early 1830's. In 1837 he and W. F. Cooke obtained their first patent for a telegraph, the "five needle" instrument, in which each letter was indicated directly by the deflections of two (magnetic) needles. Wheatstone subsequently did considerable work to develop the telegraph into a practical device. His letter-showing dial telegraph and his automatic transmitting and receiving system were particularly important. Wheatstone also worked on submarine telegraphy, performing the first experiments in 1844.

Beginning with his work on the kaleidophone, Wheatstone maintained an interest in vision and optics throughout his career. As the inventor of the stereoscope, later developed by Brewster, Wheatstone found himself—to his own surprise—the first since Leonardo da Vinci to discuss depth perception in terms of the different image received by each eye. He associated the spectrum of the light of a discharge with the metals that constituted the electrodes,⁵ and in 1848 he invented the polar clock, which determines the position of the sun from the angle of polarization of sunlight.

Wheatstone also did work on audition, vowel sounds, electrical recording devices, and the dynamo. He was interested in cryptography, decipher-

ing certain historic manuscripts and inventing a cryptograph instrument.⁶

NOTES

1. Wheatstone indicated this in his first published paper, "New Experiments on Sound" (1823). Wheatstone, *Scientific Papers*, 6.
2. *Report of the British Association for the Advancement of Science*, 2 (1832), 558.
3. The estimate was high, probably because the wire was looped back and forth, not straight. Edmund Whittaker, *A History of the Theories of Aether and Electricity*, I (New York, 1960), 228.
4. "On the Transmission of Musical Sounds," Wheatstone, *Scientific Papers*, 62–63.
5. *Report of the British Association for the Advancement of Science*, 5 (1835), pt. 2, 11–12.
6. David Kahn, *The Codebreakers* (New York, 1967), 196–198.

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